

Forest Health Protection

Pacific Southwest Region



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To: District Ranger, Warner Mountain District, Modoc National Forest

Subject: Evaluation of Top-killed White Fir on Cedar Pass (FHP Report NE04-05)

At the request of Dan Hubbard, silviculturist for the Warner Mountain RD, Danny Cluck, Forest Health Protection (FHP) entomologist, conducted a field evaluation of the Cedar Pass area on February 23, 2004. The objective of the visit was to evaluate the top die back occurring in white fir near the Cedar Pass Ski Area and provide recommendations as appropriate. Dan Hubbard and Monte White accompanied him in the field.

Background

Cedar Pass is located on Highway 299 about 10 miles west of Cedarville (Warner Mountain RD, Modoc NF). The elevation of the site is approximately 5800 feet with precipitation averaging around 25 inches per year. The north facing slopes are dominated by white fir (*Abies concolor*) with scattered ponderosa pine (*Pinus ponderosa*) and incense cedar (*Libocedrus decurrens*). The south facing slopes are mostly western juniper (*Juniperus occidentalis*), ponderosa pine and incense cedar. In the pure white fir stands there are trees ranging from saplings to large diameter (24" +) mature trees. The saplings make up scattered dense thickets underneath the canopy of densely stocked dominant and co-dominant trees. Past management activities have included selective harvesting of green trees in the early 1980's and salvage harvesting of bark beetle killed

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and live trees in the late 1990's. The stand is classified as site index 45 (Dunning and Reineke Technical Bulletin 354).

Observations

Deep snow limited vehicle access to most affected areas so all observations were made from Highway 299 and within the lower portions of the ski area. Nearly all north-facing stands observed within this limited area appear to be overstocked.

Approximately 75% of the mature white fir has been top-killed in the area we observed. Most trees have less than 5-10% of their linear crown length affected. Some trees had up to 50% crown kill and some were completely dead. Top-kill and whole tree mortality was observed in all age classes (except for seedlings and saplings). Fir engraver (*Scolytus ventralis*) beetles are active in the area as evidenced by larvae found in a completely faded 8" dbh tree. The majority of top-kill appeared to be restricted to the area of cone production. Prior to destructive sampling of some top-killed trees a clear determination cannot be made between the level of fir engraver related damage versus physiological dieback of foliage due to excessive cone production (heavy cone crops were observed by District personnel last fall)

Root disease may also be contributing to the overall decline of tree health. One stump observed within the ski area had heart rot but was too iced over to look for the conks, or fruiting bodies, of annosus root disease (*Heterobasidion annosum*). Based on past observations by FHP and District personnel, it is likely that annosus root disease is present in most pure white fir and mixed conifer stands within the Warner Mountains.

Discussion

The high level of top kill occurring in white fir in the Cedar Pass area is likely the result of fir engraver attacks and possibly some physiological dieback of foliage due to heavy cone production. District personnel observed large cone crops in white fir in this area last fall. It is not clear whether the abundant cone crop was the result of tree stress or that the cone crop resulted in tree stress leading to the die back and possible fir engraver attacks. Felling a few trees with top kill limited to the cone production area would allow for a more complete assessment of fir engraver activity. Top kill that extended below the area of cone production, including whole tree mortality, is the result of successful fir engraver attacks.

Trees that succumb to fir engraver attacks are typically predisposed by factors that compromise tree health and vigor. In the Cedar Pass area high stand density, prolonged drought, and annosus root disease are all contributing factors in the decline of tree health. All of these factors are present in the Cedar Pass area. Cedarville annual precipitation from 1999-2003 was below normal for all five years (Table 1). In addition, the long term average annual precipitation of 25" for this site is below what is generally required to sustain white fir over a generation. Therefore, even with lower stocking levels, white fir growing on this site is at a higher risk for fir engraver beetle related mortality. High stand density combined with the last prolonged drought (1987-1992) resulted in elevated levels of white fir mortality throughout the Modoc National Forest as documented in previous FHP evaluations (Schultz 1994) and aerial surveys. During this time,

the areas with the highest white fir mortality were those with less than 30" annual precipitation.

Table 1. Cedarville Annual Precipitation 1999-2003.

YEAR	Total Precipitation (in)	% Of Average (12.96")
1999	9.63	74%
2000	8.25	64%
2001	9.62	74%
2002	7.76	60%
2003	12.5	96%

Trees that only experienced a minimal amount of top kill, either as a result of last season's fir engraver attacks and/or physiological dieback of foliage due to a heavy cone crop, should survive. Based on past FHP observations and the results of an administrative study of top-killed white fir in northeastern California (Smith and Peterson 2000), trees with minimal top kill resulting from fir engraver attacks generally survive and may grow new leaders. In the case of physiological dieback, the tops may grow new foliage.

More top kill and some additional whole tree mortality should be expected this coming season. Some larger trees may fade this spring as a result of last summers successful fir engraver attacks and new attacks this summer on smaller trees and tops may result in fading by late fall. White fir trees in the Cedar Pass area will remain susceptible to high levels of mortality due to the overstocked condition of the stands, current fir engraver activity and frequent prolonged drought combined with inadequate average precipitation to maintain the species over the long term. If the area receives normal to above normal precipitation this winter some white fir may be able to replenish their defense systems and resist further successful attacks. Some trees will require more than one season with adequate moisture before they will fully recuperate their natural defenses.

A white fir levels of growing stock study conducted by Cochran (1998) on the Deschutes (Block 1) and Fremont National Forests (Blocks 2, 3, and 4) between 1983 and 1995 provides some additional information to consider when managing white fir in lower precipitation areas. Plots were thinned in 1982 and again in 1985 to a residual stand density index (SDI) of 112, 168, 224 or 280. These corresponded to growing stock levels of 20, 30, 40 or 50 percent of normal density. Elevations for his study plots ranged from 4,500 to 5,900 feet with average annual precipitation ranging from 16 to 31 inches. A general drought prevailed over the study areas from the late 1970's to the mid 1990's. Mortality between 1991 and 1995 destroyed the study. Mortality on Block 1 was attributed to root rot and defoliation by spruce budworm. Mortality on Blocks 2, 3 and 4 was attributed to fir engraver beetles. Mortality from fir engraver beetles appeared to increase with increasing stand densities and was above acceptable levels even at the lowest stand density (20 percent of density considered normal for white fir).

Healthy stands of white fir grow very rapidly, produce a dense crown cover and are visually pleasing (Cochran 1998). His results, however, raise doubts about maintaining stands with a large component of white fir in areas with mean annual precipitation rates below 32 inches even if stand densities are kept very low. These stands grew well for more than 60 years and reached

commercial size before severe mortality occurred.

Management Alternatives

(1) No action

The overstocked condition of stands in the Cedar Pass area will persist and increase over time. With this increase in stand density, and the protracted periods of below average precipitation that occur in northeast California, there is an increase in the probability of bark and engraver beetle-related mortality throughout the area. Although some mortality may be desired for snags, small openings and for future down woody debris, the no action alternative will most likely result in unacceptable levels of mortality and fuel accumulation.

(2) Mechanical Thinning

Thinning from below to a stand density below the “normal” stocking levels would effectively reduce tree competition for limited water and nutrients. Furthermore, selecting for more drought tolerant species such as ponderosa pine and incense cedar over white fir will increase species diversity and make the stand more resilient to disturbance agents such as insects, disease, and fire. Thinning can also decrease the need to enter stands to conduct salvage operations, decrease the amount of fuel loading and reduce the number of hazard trees. When carrying out thinning treatments, it is recommended that a registered borate compound be applied to all freshly cut stumps >8” dbh. This will reduce the chance of successful colonization of stumps by spores of *Heterobasidion annosum*.

Forest Health Protection can assist with the funding for bark beetle prevention projects in overstocked areas within and adjacent to the Cedar Pass. If you are interested in this funding please contact any of the Forest Health Protection entomology staff for assistance in developing and submitting a proposal.

If you have any questions regarding this report and/or need additional information please contact us at 530-251-2151

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Fir Engraver

The fir engraver attacks red and white fir in California. Fir engraver adults and developing broods kill true firs by mining the cambium, phloem, and outer sapwood of the bole, thereby girdling the tree. Trees greater than 4" in diameter are attacked and often killed in a single season. Many trees, weakened through successive attacks, die slowly over a period of years. Others may survive attack as evidenced by old spike-topped fir and trees with individual branch mortality. Although many other species of bark beetles cannot develop successful broods without first killing the tree, the fir engraver beetle is able to attack and establish broods when only a portion of the cambium area has been killed.

Evidence of Attack

Fir engravers bore entrance holes along the main stem, usually in areas that are > 4" in diameter. Reddish-brown or white boring dust may be seen along the trunk in bark crevices and in spider webs. Some pitch streamers may be indicative of fir engraver attacks; however, true firs are known to stream pitch for various reasons and there is not clear evidence that pitch streamers indicate subsequent tree mortality or successful attack. Resin canals and pockets in the cortex of the bark are part of the tree's defense mechanism. Beetle galleries that contact these structures almost always fail to produce larval galleries as the adults invariably abandon the attack. Pitch tubes, often formed when bark beetles attack pine, are not produced on firs.

Adults excavate horizontal galleries that engrave the sapwood; the larval galleries extend at right angles along the grain. Attacks in the crown may girdle branches resulting in individual branch mortality or "flagging". Numerous attacks over part or all of the bole may kill the upper portion of the crown or the entire tree. A healthy tree can recover if sufficient areas of cambium remain and top-killed trees can produce new leaders. The fir engraver is frequently associated with the roundheaded fir borer and the fir flatheaded borer.

Life Stages and Development

In the summer, adults emerge and attack new host trees. The female enters the tree first followed by the male. Eggs are laid in niches on either side of the gallery. Adult beetles carry a brown staining fungi, Trichosporium symbioticum, into the tree which causes a yellowish-brown discoloration around the gallery. The larvae mine straight up and down, perpendicular to the egg gallery. Winter is commonly spent in the larval stage, with pupation occurring in early spring. In most locations, the fir engraver completes its life cycle in 1 year, however at higher elevations 2 years may be required.

Conditions Affecting Outbreaks

Fir engravers bore into any member of the host species on which they land but establish successful galleries only in those which have little or no resistance to attack. Populations of less aggressive species like fir engraver are likely to wax and wane in direct relationship to the stresses of their hosts. Drought conditions often result in widespread fir mortality however attempting to determine when outbreaks will occur is difficult. Lowered resistance of trees

appears to be a contributing factor. Overstocking and the increased presence of fir on sites that were once occupied by pine species may also contribute to higher than normal levels of fir mortality. Several insect predators, parasites and woodpeckers are commonly associated with the fir engraver and may help in control of populations at endemic levels.

Annosus Root Disease

Heterobasidion annosum is a fungus that attacks a wide variety of woody plants. All western conifer species are susceptible. Madrone (*Arbutus menziesii*), and a few brush species (*Arctostaphylos* spp. and *Artemisia tridentata*) are occasional hosts. Other hardwood species are apparently not infected. The disease has been reported on all the National Forests in California, with incidence particularly high on true fir in northern California, in the eastside pine type forests, and in southern California recreation areas.

Annosus root disease is one of the most important conifer diseases in the Region. Current estimates are that the disease infests about 2 million acres of commercial forest land in California, resulting in an annual volume loss of 19 million cubic feet. Other potential impacts of the disease include: increased susceptibility of infected trees to attack by bark beetles, mortality of infected trees presently on the site, the loss of the site for future production, and in recreation areas, depletion of vegetative cover and increased probability of tree failure and hazard.

During periods favorable to the fungus, fruiting bodies (conks) form in decayed stumps, under the bark of dead trees, or under the duff at the root collar. New infection centers are initiated when airborne spores produced by the conks land and grow on freshly cut stump surfaces. Infection in true fir may also occur through fire and mechanical wounds, or occasionally, through roots of stumps in the absence of surface colonization. From the infected stump surface, the fungus grows down into the roots and then spreads via root-to-root contact to adjacent live trees, resulting in the formation of large disease centers. These infection centers may continue to enlarge until they reach barriers, such as openings in the stand or groups of resistant plants. In pines, the fungus grows through root cambial tissue to the root crown where it girdles and kills the tree. In true fir and other non-resinous species, the fungus sometimes kills trees, but more frequently is confined to the heartwood and inner sapwood of the larger roots. It then eventually extends into the heartwood of the lower trunk and causes chronic decay and growth loss.

Heterobasidion annosum in western North America consists of two intersterility groups, or biological species, the 'S' group and the 'P' group. These two biological species of *H. annosum* have major differences in host specificity. All isolates of *H. annosum* from naturally infected ponderosa pine, Jeffrey pine, sugar pine, Coulter pine, incense cedar, western juniper, pinyon, and manzanita have, to date, been of the 'P' group. Isolates from true fir and giant sequoia have been of the 'S' group. This host specificity is not apparent in isolates from stumps; with the 'S' group being recovered from both pine and true fir stumps. These data suggest that infection of host trees is specific, but saprophytic colonization of stumps is not. The fungus may survive in infected roots or stumps for many years. Young conifers established near these stumps often die shortly after their roots contact infected roots in the soil.

